Research on Adaptive Tracking of University Funding Objects from the Perspective of Big Data

Yuliang Zhang(✉) and Xiaoyan Xu

Data and Information Center, Wuxi Vocational Institute of Commerce, Wuxi 214000, China
zhangyuliang2@wxic.edu.cn

Abstract. It is necessary to track the funding objects of colleges and universities adaptively to understand the effect of funding for poor students. For this reason, an adaptive tracking method for university funding objects is proposed from the perspective of big data. The tracking indicators are selected through the Delphi method, and the "background", "input", "response", and "output" form a pyramid tracking indicator system based on the CIRO evaluation model. The entropy weight method is used to calculate the weight of each tracking index of the system. Combining with the index membership degree, an adaptive tracking model of university funding objects is constructed to realize the analysis of funding effectiveness. The results show that the performance score of the three funded students has been increasing year by year, which indicates that the status of the three students has been significantly improved after receiving funding, but from the growth trend, the score of student 1 has entered a flat development period after getting better, which indicates that the status is stable and the funding can be gradually reduced. The score of student 2 shows a rising trend, but the rising trend is slow, so it is necessary to increase funding. Student 3 has been growing, and the score has not stabilized, so we can continue to maintain the current funding.

Keyword: University Funding Objects · CIRO · Tracking Index System · Weight · Adaptive Tracking Method

1 Introduction

In recent years, with the expansion of enrollment in universities, the number of financially disadvantaged students has been increasing. To provide greater financial support to economically disadvantaged university students and ensure their smooth access to education, efforts have been made to eliminate poverty through education, promote educational equity, and foster social harmony. By offering financial assistance to eligible students, universities can improve their learning conditions and outcomes, thus promoting social fairness. However, university aid recipients are diverse and complex, varying in terms of personal backgrounds, family economic situations, and learning needs. Aid recipients may experience changes over time, necessitating the establishment of an adaptive tracking approach to timely and accurately understand their evolving needs.

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With the development and widespread application of information technology, universities have begun utilizing relevant technical means to enhance aid recipient management. Adaptive tracking techniques adjust tracking algorithms and models dynamically based on different circumstances and requirements, providing more accurate and real-time information about aid recipients. Currently, there are several main methods for adaptive tracking of aid recipients, including the Coyle model, Kaufman's five-level evaluation model, the CIRO model, the CIPP model, and Phillips' return on investment model. Compared to other models, the CIPP and CIRO models place greater emphasis on evaluating all elements of aid recipients and the implementation process of aid measures. Particularly, they prioritize the analysis of background factors related to aid needs, showcasing more advanced systematic thinking and ensuring the scientific rigor and integrity of tracking research. While the background evaluation, input evaluation, and outcome evaluation in both models are generally similar, the key difference lies in the third stage. In this stage, the CIPP model emphasizes comprehensive tracking and evaluation of aid measures throughout their implementation, providing timely feedback to organizers to facilitate adjustments and improvements and offer insights for subsequent aid organization. On the other hand, the CIRO model emphasizes relying on the subjective information of aid recipients, considering that the improvement of aid relies on collecting and utilizing the recipients' feedback. Based on the aforementioned analysis, this study believes that the CIRO model is more suitable for the research topic. Therefore, leveraging the CIRO model, a university aid recipient adaptive tracking model in the context of big data is constructed. The Delphi method is employed to select tracking indicators, and the CIRO evaluation model serves as the framework, forming a pyramid-shaped tracking indicator system consisting of "Background," "Input," "Reaction," and "Output." The weights of each tracking indicator in the system are calculated using the entropy weight method. Combining with indicator membership degrees, the university aid recipient adaptive tracking model is established to analyze the effectiveness of aid. The research on university aid recipient adaptive tracking in the context of big data provides new ideas and methods for aid recipient management. By leveraging data-driven decision support, real-time monitoring and prediction capabilities, personalized services and resource optimization, as well as intelligent decision-making and risk management, the efficiency and quality of university aid recipient management can be improved, better meeting the needs of aid recipients.

2 CIRO Based Adaptive Tracking Model for Funded Objects

The state has successively introduced a series of financial aid policies for students with financial difficulties from families, increased the amount of financial aid to college students, basically met the material needs of students with financial difficulties from families, and ensured that students with financial difficulties from families can enjoy the right and opportunity to receive higher education fairly. It reflects the concern and care of the Party and the state for students from poor families. However, we must also be soberly aware that there are also some unsatisfactory problems [3] in the funding work for poor college students. In order to ensure the effective implementation of funding measures, it is necessary to carry out adaptive tracking of funding objects. The CIRO

model was proposed by Warr, Bird and Rackham in 1970. CIRO is the first letter of the four evaluation activities of Context Evaluation, Input Evaluation, Reaction Evaluation, and Output Evaluation in the model, which are translated as background evaluation, input evaluation, response evaluation, and result evaluation. See Table 1 for CIRO model.

Table 1. CIRO Model

Assessment activities	Content
Context evaluation	Determine funding needs and goals based on the current environmental background
Input evaluation	Collect and summarize relevant information and decide on funding inputs
Reaction evaluation	Collect and analyze feedback from funding recipients to improve funding activities
Outcome evaluation	Obtain the results after funding and compare them with previous goals as a reference for the next funding activity

2.1 Selection of Adaptive Tracking Indicators for University Funding Objects

The CIRO evaluation model is used as the framework to build an adaptive tracking indicator system for university funding objects, and four first level tracking indicators, namely "background", "input", "response" and "output", are determined. Under each indicator, several second level indicators are designed, and under each second level indicator, several third level indicators are designed, forming a pyramid shaped tracking indicator system. The following methods are mainly used to select and determine specific tracking indicators:

First, literature analysis. The author of this article has consulted a large number of research articles and documents on civil servant training, online training, performance evaluation, education and teaching, summarized and sorted out the content of the indicator design on training performance, referred to the research results of experts and scholars, and pre-selected the representative indicators that are strongly related to civil servant online training. On the basis of in-depth analysis, the hierarchy is determined, the classification is carried out, and the importance of different indicators is considered, the preliminary ranking is made, and the pre-selected indicator set [4] is constructed.

Second, expert consultation method. The index system preliminarily determined after pre selection has consulted the opinions of relevant experts through letters, interviews and other forms. Among these experts, there are teachers in charge of relevant work in colleges and universities, party schools and other institutions, as well as staff specially responsible for this work, which is quite representative. In the consultation process, experts do not have horizontal contact with each other, but only communicate with the author of this article in a two-way way, ensuring the independence and objectivity of expert opinions.

After repeated solicitation, induction, revision and summary, a preliminary tracking index system has been formed. The list of preliminary indicators is shown in Table 2.

Table 2. List of preliminary tracking indicators

Category	Index
Background	The importance attached by the school to funding
	Poor students' understanding of subsidy policies
	Attitudes of impoverished students towards participating in funding
	Pre funding needs survey
	Matching funding objectives with needs
Input	Recognition system for family economic difficulties
	Selection work system
	The distribution system of funding
	System for the use of funding
	The funding plan is reasonable and appropriate
	Supporting institutional construction
	Proportion of special funds invested in funding
	Diversity of funding methods
	Promotion of funding policies
Reaction	Legitimacy of funding organizations
	Funding policy construction and implementation status
	The completeness of funding policies
	Rationality of the use of funding resources
	Repayment status of student loans
	Employment situation of impoverished students
Output	Student learning ability
	Family status of impoverished students
	The Psychological Status of Poor Students
	Student's sense of responsibility
	Social public satisfaction

On the basis of the selected preliminary tracking indicators, further selection is needed to reduce the indicator dimension and build the final adaptive tracking indicator system for university funding objects. Delphi method is an expert investigation method with prescribed procedures, which absorbs the advantages of expert meeting method and overcomes the disadvantages of expert meeting method. Its basic principle is to put forward questions to the selected experts in the form of investigation and consultation, summarize and sort out the experts' opinions, and then anonymously feedback the

obtained opinions to each expert, ask for opinions again, sort out again, and feed back again until the opinions are consistent [5]. The process of selecting tracking indicators by Delphi method is as follows:

Step 1: form an expert group and issue questionnaires. The questionnaire lists six basic evaluation indicators and supplementary evaluation indicators that need expert empowerment. In addition, all background information about the PPP project should be attached for experts' reference.

Step 2: The experts will score each indicator according to the information received, and explain how to use these information to propose scoring values.

Step 3: collect the questionnaires and conduct the first induction statistics. The coordination degree of experts' opinions is calculated according to the scores of experts on various indicators. The degree of coordination of expert opinions refers to whether the experts participating in the correspondence have differences on the indicators, which is usually expressed by the coefficient of variation and Kendall's coefficient of harmony W. The coefficient of variation indicates the coordination degree of experts on the relative importance of an indicator, the rationality of the calculation formula, and the operability of the collection method. The more the coefficient, the higher the coordination degree among experts [6]. It is generally believed that the coefficient of variation should be less than 0.25. The calculation formula is as follows:

$$\lambda_j = \frac{\left(\beta_j - \overline{x}_j\right)^2}{\overline{x}_j} \tag{1}$$

Among them,

$$\overline{x}_j = \frac{\sum_{i=1}^{m} \eta_{ij}}{m} \tag{2}$$

$$\beta_j = \sqrt{\frac{\sum_{i=1}^{m} \left(\eta_{ij} - \overline{x}_j\right)^2}{m-1}} \tag{3}$$

where, λ_j On behalf of the j Coefficient of variation of item tracking index; η_{ij} On behalf of the i Experts j Scoring of item tracking indicators; $\overline{x}_j$ On behalf of the j Average value of item tracking indicators; β_j On behalf of the j Standard deviation of item tracking indicators; m Number of representative experts.

If the coefficient of variation is greater than 0.25, it means that the scoring opinions of various experts are quite different, and the second round of scoring and research will be carried out.

Step 4: distribute the scores of other experts and the results of summary statistics to all experts anonymously so that they can refer to and modify their own opinions. This process is repeated until experts no longer revise their opinions.

2.2 Weight Calculation of Tracking Indicators

Since there are many tracking indicators, each indicator is very important to the rationality of the weight value of the final evaluation result. In theory and practice, common weight calculation methods can be divided into subjective and objective methods.

(1) Subjective weighting method

The subjective weighting method is a method to collect the views of relevant professionals on various indicators through specific means, and determine the weight by integrating their views. The commonly used subjective weighting methods are: binomial coefficient method, classification scoring method, expert survey method, analytic hierarchy process, etc. [7]. The subjective weighting method is easy to operate, and can better reflect the ideas of experts or management. However, this method is very subjective and arbitrary, and may not completely objectively reflect the actual weights between indicators.

(2) Objective weighting method

The objective weighting method is a method that uses a specific calculation method to calculate and analyze the collected data to determine the weight of each indicator. The commonly used objective weighting methods include principal component analysis, factor analysis, correlation analysis, multi day scale planning, etc. The advantage of this method is that the weight does not depend on one observation and one score, and it is based on mathematical theory. However, its disadvantage is that the amount of sample data collected is large, the calculation method is relatively complex, and generally does not reflect the experts' views on the weight of different indicators [8]. Therefore, there may be a large discrepancy between the weight and the actual weight of the indicator.

In this paper, because there are many tracking indicators for the funded objects, including both qualitative indicators and quantitative indicators, considering the characteristics of subjective and objective weighting methods, it is difficult to ensure the accuracy of the indicator weights by using only one method, and it is also difficult to apply to the actual situation. Therefore, the research adopts the entropy weight method to determine the weight of each index, and make appropriate corrections according to the actual situation to maintain the scientificity, objectivity and rationality of the index. Entropy weight method is a method to determine the weight of indicators according to the amount of information contained in each indicator in the evaluation indicator system. Entropy weight method is an objective method to assign weight. The entropy weight method uses the entropy value in the information theory to reflect the degree of information disorder in different indicators, so as to measure the amount of information contained in an indicator, so as to determine the role of the indicator in target decision-making [9]. At present, entropy weight method has been applied in most fields, and the application fields are relatively wide. The specific steps of entropy weight method are as follows:

Step 1: Construct a judgment matrix according to the established indicator system. For the whole indicator system, if an indicator system has n funding objects and m tracking indicators, then n consists of n funding objects and m tracking indicators × The

m-order judgment matrix is:

$$D = \left(d_{ij}\right)_{nm} = \begin{bmatrix} d_{11}\ d_{12}\ \ldots\ d_{1m} \\ d_{21}\ d_{22}\ \ldots\ d_{2m} \\ \ldots\ \ldots\ \ldots\ \ldots \\ d_{n1}\ d_{n2}\ \ldots\ d_{nm} \end{bmatrix} \tag{4}$$

where, d_{ij} No i Objects evaluated in the j Evaluation value under tracking indicators.

Step 2: preprocess the constructed judgment matrix.

The indicator system of this paper involves some very large indicators and very small indicators. According to the principle of preferential membership, different types of indicators have different standardized processing methods. In this paper, the extremely large indicators in the matrix are processed as follows:

$$g_{ij} = \frac{d_{ij} - \min d_{ij}}{\max d_{ij} - \min d_{ij}} \tag{5}$$

The processing method for extremely small indicators in the matrix is:

$$g_{ij} = \frac{\max d_{ij} - d_{ij}}{\max d_{ij} - \min d_{ij}} \tag{6}$$

The decision matrix is finally obtained by processing the constructed judgment matrix:

$$G = \left(g_{ij}\right)_{nm} = \begin{bmatrix} g_{11}\ g_{12}\ \cdots\ g_{1m} \\ g_{21}\ g_{22}\ \cdots\ g_{2m} \\ \cdots\ \cdots\ \cdots\ \cdots \\ g_{n1}\ g_{n2}\ \cdots\ g_{nm} \end{bmatrix} \tag{7}$$

Step 3: Calculate E_{ij}, i.e. j Index i The proportion of financial aid recipients. E_{ij} The specific calculation method of is as follows.

$$E_{ij} = \frac{g_{ij}}{\sum_{i=1}^{n} g_{ij}} \tag{8}$$

Step 4: Pass the calculated No j Index i Proportion of target indicators of financial aid E_{ij}, calculate the entropy weight of each index e_j. e_j The specific calculation method of is as follows:

$$e_j = \frac{\sum_{i=1}^{n} E_{ij} \ln E_{ij}}{\ln n} \tag{9}$$

According to the basic principle of logarithmic function, the value of logarithm cannot be 0. In this case, it is generally specified that when $E_{ij} = 0$ When, $E_{ij} \ln E_{ij} = 0$.

Step 5: According to the calculated entropy value e_j, find the j Weight of indicators s_j. Section j Weight of indicators s_j The calculation method of is as follows:

$$s_j = \frac{1 - e_j}{\sum_{j=1}^{m} (1 - e_j)} \tag{10}$$

It can be seen from the above formula that the formula meets $0 \leq s_j \leq 1$, $\sum_{j=1}^{m} s_j = 1$. At the same time, it can be concluded from the formula that the entropy value e_j When increasing, the weight of the indicator s_j reduce; Entropy e_j Weight of indicators when decreasing s_j enlarge. Therefore, it can be summarized as follows: in the established indicator system, the smaller the entropy value of an indicator, the greater the change degree of the indicator value, the more information can be provided for the system, and the greater the role in the comprehensive evaluation, that is, the greater the weight of the indicator; When the entropy value of an indicator in the indicator system is larger, it indicates that the smaller the change degree of the indicator value is, the less information can be provided for the system, and the smaller the role it plays in the comprehensive evaluation, that is, the smaller the weight of the indicator. Weight s_j It reflects the information amount of each indicator, and can intuitively reflect the difference between each indicator. The larger the entropy weight value is, the greater the impact of this indicator on decision-making.

To make $\ln E_{ij}$ Meaningful, general assumption $E_{ij} = 0$ When, $E_{ij} \ln E_{ij} = 0$, but when $E_{ij} = 1$ When, $E_{ij} \ln E_{ij} = 0$, obviously not tangential, and contrary to the meaning of entropy, we can E_{ij} Revised and defined as:

$$\tilde{E}_{ij} = \frac{1 + g_{ij}}{\sum_{i=1}^{n} (1 + g_{ij})} \tag{11}$$

Then calculate the entropy weight of each index $\tilde{e}_j$,

Then we can calculate the j The weight of each indicator is removed.

$$\tilde{s}_j = \frac{1 - \tilde{e}_j}{m - \sum_{j=1}^{m} \tilde{e}_j} \tag{12}$$

In order to facilitate the subsequent unified operation, the weight obtained in the two cases s_j, $\tilde{s}_j$, uniformly called w_j.

2.3 Tracking Model Construction

Based on the weight of tracking indicators calculated above, a tracking model is constructed to analyze the effectiveness of funding.

(1) Tracking index membership

The determination of membership degree of tracking index is a key link in the application of fuzzy comprehensive evaluation. Because the evaluation of something is always complicated and fuzzy, it is inevitable that there will be personal subjective color when establishing the membership degree of the evaluation index, which virtually increases the complexity, fuzziness and diversity of the membership function. In the tracking of the effect of financial aid for poor college students, the effect grade is divided into "excellent", "good", "average" and "poor". Through empirical research, the evaluation value of a college can be determined, and the corresponding index value of the evaluation set can be determined. Its membership can be expressed as $V = \{v_1, v_2, v_3, v_4\}$. In particular, it is worth noting that the method of collecting data through questionnaires is used to determine the subordination matrix of the financial aid effectiveness of poor college students. There must be enough evaluators and the evaluators must have a good understanding of the financial aid work of poor college students to ensure that the degree of subordination is in line with the objective reality to the maximum extent [10]. The constructed tracking index membership matrix is as follows:

$$V = \left(v_{ij}\right)_{mn} = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix} \tag{13}$$

Among them, v_{ij} Indicator j For comments i Membership, v_{ij} The value of is determined by questionnaire.

(2) Tracking model

combination w_j, v_{ij} Establish tracking model.

$$Y = W \cdot V = [w_1, w_2, ..., w_m] \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix} \tag{14}$$

Among them, Y Represent the corresponding results of the funded objects on evaluation set V; W Represents a set of weights.

The tracking set of funding effectiveness for poor college students can be expressed as V = [excellent, good, average, poor]. Because of the fuzziness and uncertainty of language comments, they can be expressed in the form of a percentage system, thus transforming qualitative analysis into quantitative analysis. The quantitative table is shown in Table 3 below.

Table 3. Classification of funding effectiveness

Grade	Fraction
Excellent	[90, 100)
Good	[75,90)
Commonly	[60,75)
Poor	[0,60)

Finally, the results are normalized to get the final tracked results.

3 Tracking Model Application Test

Taking three poor students in a university as an example, the tracking model studied is used to track the effectiveness of the funding to test the effectiveness of the tracking model studied.

3.1 CIRO Tracking Index System

After four rounds of expert scoring, the experts reached an agreement on the final tracking index system as shown in Table 4.

Table 4. CIRO tracking index system

Primary	Secondary	Third level	c_j
Effectiveness of university funding	Background	The importance attached by the school to funding	0.1263
		Poor students' understanding of subsidy policies	0.2153
		Pre funding needs survey	0.0263
		Matching funding objectives with needs	0.1262
	Input	Recognition system for family economic difficulties	0.0362
		The distribution system of funding	0.2023
		System for the use of funding	0.2156
		Proportion of special funds invested in funding	0.2325

(*continued*)

Table 4. (*continued*)

Primary	Secondary	Third level	c_j
	Reaction	Funding policy construction and implementation status	0.1548
		The completeness of funding policies	0.1632
		Rationality of the use of funding resources	0.1478
		Repayment status of student loans	0.1852
		Employment situation of impoverished students	0.2020
	Output	Student learning ability	0.1782
		Family status of impoverished students	0.069
		The psychological status of poor students	0.1585
		Student's sense of responsibility	0.1263
		Social public satisfaction	0.2214

3.2 Tracking Index Weight

Use the improved entropy weight method to calculate the weight of each indicator in Table 4, and the calculation results are shown in Fig. 1 and Table 5 below.

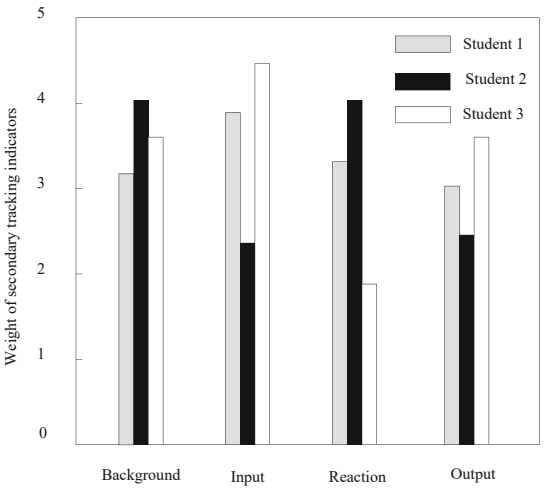

Fig. 1. Weight of secondary tracking indicators

Table 5. Weights of three-level tracking indicators

Third level	Student 1	Student 2	Student 3
The importance attached by the school to funding	0.5482	2.4862	1.0122
Poor students' understanding of subsidy policies	0.1485	3.4527	2.2254
Pre funding needs survey	0.2485	5.4865	4.5662
Matching funding objectives with needs	1.5672	1.4852	3.0214
Recognition system for family economic difficulties	2.3214	2.4752	5.0255
The distribution system of funding	1.2355	3.3312	2.0363
System for the use of funding	1.14682	3.2014	2.4874
Proportion of special funds invested in funding	2.4542	2.0141	0.3622
Funding policy construction and implementation status	1.6782	0.3969	3.6215
The completeness of funding policies	0.7822	0.5285	4.1256
Rationality of the use of funding resources	0.3755	2.3631	1.5245
Repayment status of student loans	2.6725	2.3244	3.1142
Employment situation of impoverished students	1.8452	2.0202	2.0235
Student learning ability	3.8545	3.3692	2.2687
Family status of impoverished students	2.8752	0.4587	1.3625
The psychological status of poor students	0.5458	1.2045	1.4782
Student's sense of responsibility	0.3255	2.5287	0.3034
Social public satisfaction	2.7845	3.1011	0.3969

3.3 Tracking Results

The tracking model is used to track the three funded students for four years, and the tracking effect is shown in Fig. 2 below.

As can be seen from Fig. 2, the performance score of the three funded students has been increasing year by year, which indicates that the three students have significantly improved their status in all aspects after receiving funding, but from the growth trend, the score of student 1 has entered a flat development period after improving, which indicates that the status is stable and the funding can be gradually reduced. The score of student 2 shows a rising trend, but the rising trend is slow, so it is necessary to increase funding. Student 3 has been growing, and the score has not stabilized, so we can continue to maintain the current funding.

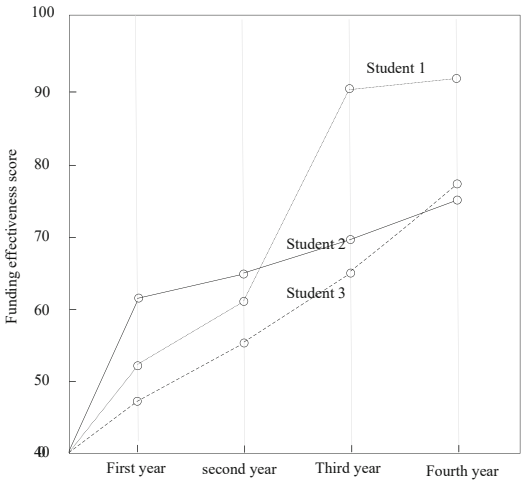

Fig. 2. Tracking Results of Funding Objects

4 Conclusion

The school provides financial aid to students. First, it investigates the family situation of students, and uses home visits and other forms to investigate the economic situation of students' families on the spot. Then it inspects the students themselves in various aspects at the school. In addition to the basic family situation, there are also various aspects of students' academic achievements, students' enthusiasm for learning, and students' popularity. After the investigation of these aspects, the school can report the basic information of applicants to the funding unit, and then apply for funding. School funding often ends at this stage, or it is usually after obtaining funding, the funding project will stagnate, and students can not get timely funding, which leads to poor results of funding, and funding is invalid. This requires colleges and universities to participate in the whole process of funding, so as to ensure the funding results of colleges and universities. Under the guidance of the concept of targeted poverty alleviation in the new era, university funding should not only provide autonomy for students in funding, but also provide funding and observation for other aspects of students' life and learning. It should also accurately target difficult target groups, and should not use the funding funds in places where they should not be used. In the new era, colleges and universities should not only set up a dynamic tracking system for students' growth and expand the scope of the school's funding, but also set up a hierarchical funding system to track the whole process of student funding, so as to ensure that the funded students are qualified groups. Through these measures, we can better ensure the quality of university funding by tracking university funding and its effect. For this reason, it is very necessary to carry out adaptive tracking of university funding objects from the perspective of Big data. According to the ideas and principles of CIRO model, Delphi method is applied, and relevant experts and scholars are consulted to determine the tracking index system of university funding objects for poor students. Calculate the weight of each tracking indicator in the system using the entropy weight method. Construct an adaptive tracking

model for university funding objects based on indicator membership, and obtain relevant tracking results. Taking three impoverished students from a certain university as an example, the effectiveness of the study was demonstrated through empirical analysis. In the future, adaptive tracking research on university funding objects from the perspective of Big data can focus on data quality and privacy protection, prediction and early warning capabilities, personalized services and resource optimization, effect evaluation and decision support, as well as cross field cooperation and innovation. These research directions will further promote the development of the management of university funding recipients, improve the effectiveness of funding and student satisfaction, and promote the realization of educational equity and social harmony.

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